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ADAPTING AND TESTING OF AGRICULTURAL SIMULATION MODEL TO SECTOR ANALYSIS

Contract AID/csd-2975
U. S. Agency for International Development

Agricultural Sector Analysis and Simulation Projects
Department of Agricultural Economics
Center for International Studies
Michigan State University
East Lansing, Michigan

June 30, 1972

CONTENTS

I. SUMMARY

The most important accomplishment during the past year was the integration of the generalized system simulation approach with the traditional sector analysis approach in the preparation of the Korean Agricultural Sector Study (KASS Report), a joint effort involving researchers from both the Agricultural Economics Research Institute of the Ministry of Agriculture and Forestry in Seoul, Korea, and Michigan State University. The direct adaptation of several components of the Nigerian Agricultural Simulation Model and the experience gained by the M. S. U. Simulation Team in developing that model (under AID/csd-1557) greatly expedited the development of a partial simulation model of the Korean agricultural sector which was used to make projections of the consequences of four alternative development strategies. It would not have been possible to complete the Korean Agricultural Sector Study within the ten months allowed for the study without utilizing the efficiencies of the general system simulation approach. As a result of the combined sector-simulation methodology, the costs of sector analyses are decreasing. In particular, the cost of KASS was considerably less than the cost of the agricultural sector study of Nigeria which was carried out from 1965 to 1968. Effort is now underway to train Koreans in the use of the system simulation methodology in the analysis of agricultural policies, programs and projects.

During the past year the project's activities concerning Nigeria took two forms. At the request of the Nigerian government, simulation analyses were made of some key policy issues facing the Federal Ministry of Agriculture and Natural Resources (FMANR) in its preparation of the "Perspective Plan for Agriculture in Nigeria to 1985." Concurrently with this work, and supported by it, efforts were made to develop a long term project in Nigeria to institutionalize the generalized system simulation approach within the planning and policy-making apparatus in the FMANR. At the end of the project's first year, negotiations with the Federal Government of Nigeria were still under way.

Adaptations of the Nigerian beef model have been applied in Venezuela by an Oregon State University team and are currently being developed for Colombia as part of an M. S. U. doctoral dissertation.

Though work was started on a software library, it was delayed in accordance with the original wording of the contract by the press of work resulting from the tasks reported above. Experience in implementation projects will help indicate how the software library should be organized.

II. RESEARCH ACTIVITIES DURING THE PAST YEAR

Korean Agricultural Sector Study

This study was financed jointly by the Government of the Republic of Korea and the United States Agency for International Development (USAID). On the Korean side, the Agricultural Economics Research Institute (AERI) is the implementing agency. On the U. S. side, the Department of Agricultural Economics of Michigan State University is the implementing agency. The joint organization of AERI and MSU is called the Korean Agricultural Sector Study (KASS).

The Korean Government has provided the physical facilities of AERI and the services of a large number of Korean researchers from outside as well as within AERI and has covered considerable computational costs. The U. S. has provided the services of the Agricultural Economics Department at MSU under AID/ead-184 Korea. Work under the contract is coordinated with and draws: (1) support from the results of AID/csd-1557 and (2) both personnel and results from the current contract, AID/csd-2975. The latter contracts were or are between TAB/AID/W and MSU, for the purpose of developing analytical techniques and capacity to do a more economical and effective agricultural sector analysis.

Some history of the origin of these contracts is in order at this point. One of the origins of these contracts was in an agricultural sector study for Nigeria[1] somewhat similar to the present study. That study was based on an informal, generalized systems simulation approach which was not computerized. Though consideration was given to computerizing computational routines and techniques in that study, they were not because the necessary conversions of informal components into formal mathematical computing instructions and routines had not been carried out.[2] The high cost of the

[1] CSNRD 33.

[2] T. J. Manetsch, *et al.* *A Generalized Simulation Approach to Agricultural Sector Analysis with Respect to Nigeria*. Institute of International Agriculture, Michigan State University, East Lansing, Michigan, 1971.

Nigerian "paper and pencil" sector study and the limited usefulness of other more specialized sector studies made it clear that more formal, cheaper and more efficient general computerized models were needed.

The Agency for International Development therefore contracted with Michigan State University to develop such a model along with the necessary formal mathematical computing instructions and routines sometimes referred to as "software." Though the Nigerian agricultural sector was modeled by MSU in carrying out its contract with AID, the work was done so that the model components and associated computing instructions and routines would be useful in a wide variety of situations and countries. For instance, one demographic component and associated routines have been modified and adpated repeatedly for modeling rural and urban human populations, beef herds and national palm groves. Much of the KASS model is a direct transfer of immediately useful components from earlier work. It was the availability of software components (from the MSU/AID contract) which could be reassembled in ways applicable to Korean agriculture which made it possible in a period of only seven months to assemble the necessary descriptive information; determine how the Korean agricultural sector is structured, operates, and responds to policy alternatives; and then to develop and write up a preliminary report on recommendations for developing Korean agriculture over the next 15 years. Without the improved analytical techniques from contracts AID/csd-1557 and 2975 and the experience gained under these contracts, it would not have been possible to complete the research reported here in the time in which it was done for even twice what it has cost. This project illustrates, very nicely, the advantages of combining central funding to improve techniques and analytical methods with mission funding of problematic research.

Alternative Strategies Examined

In the attainment of its objectives, the Korean Agricultural Sector Study (KASS) examined the consequences of pursuing three alternative strategies for agricultural sector development and then developed a fourth recommended strategy, also presented in the report. The first policy alternative, broadly speaking, involves continuation to 1985 of policies outlined in the Third Five-Year Plan (TFYP) for Korea for the years 1972-1976. The major goals of the plan are an increase in the level of food self-sufficiency and increased growth of rural income. This alternative includes relatively high food grain prices to stimulate supply and inhibit demand and substantial investments in programs and projects to expand agricultural production. Alternative II accepts the goals of the TFYP but seeks more effective and efficient attainment by reallocation of the public budget for rural development and modification of the regulatory policies of the TFYP. Specifically, Alternative II includes higher food grain prices than Alternative I, increased emphasis on population control, and substantial increases in budget allocations to research and extension efforts to improve the level and extent of application of agricultural technology. The third policy alternative is an abrupt departure from Alternatives I and II; this alternative moves the agricultural sector of Korea toward greater reliance on the competitive market domestically and toward free trade in world markets for agricultural inputs and outputs. Public policies are directed into areas which will stimulate and enhance the adjustments to free market conditions.

The impact of these alternative policies upon a number of performance criteria (agricultural income, value added, imports/exports, per capita incomes and nutritional levels, etc.) were projected through time from 1971 to 1985. Extensive use of simulation models was made in this analysis and projection work. Much of what follows will describe these models and their application to the sector analysis.

Overall Model Description

Figure 1 illustrates the scope of a comprehensive agricultural sector model envisioned for Korea. The broad outlines of the model used to make sector analysis projections are shown in Figure 2. This appendix presents a general description of the model of Figure 2 and its use in projecting the performance of the Korean agricultural sector under three alternative policy strategies. As shown in the diagram the model disaggregates agricultural production into 19 commodities or commodity groups.[3] These commodities were selected on the basis of current or potential importance and include such

[3] They are: (1) rice, (2) barley, (3) wheat, (4) other grains, (5) fruits, (6) pulses, (7) vegetables, (8) potatoes, (9) tobacco, (10) forage, (11) silk, (12) industrial crops, (13) beef, (14) milk, (15) pork, (16) chicken, (17) eggs, (18) fish, and (19) agricultural residual.

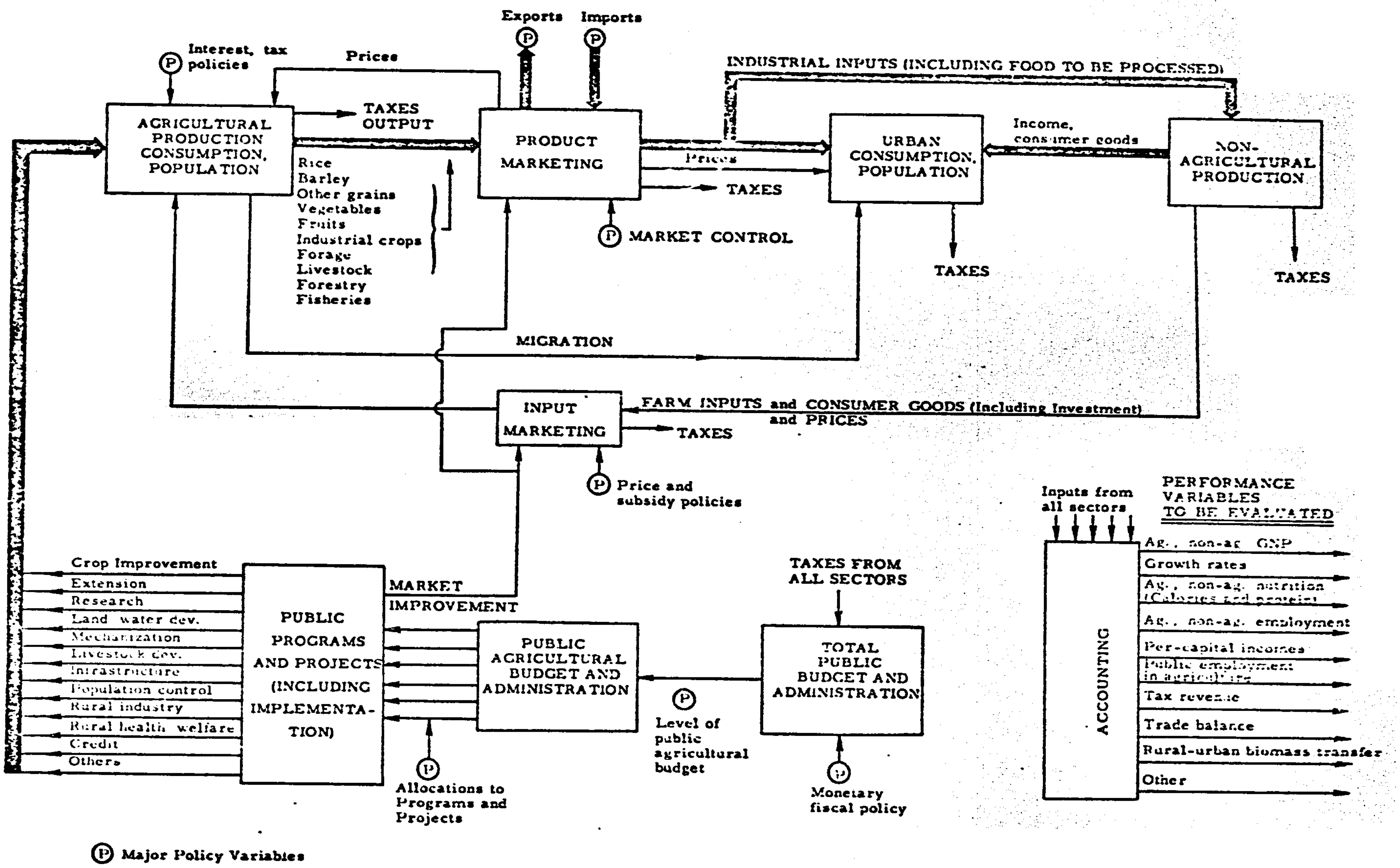

Figure 1. Korean Agricultural Sector Analysis: Major Sub-Sectors, Flows, Outputs, and Policy Inputs

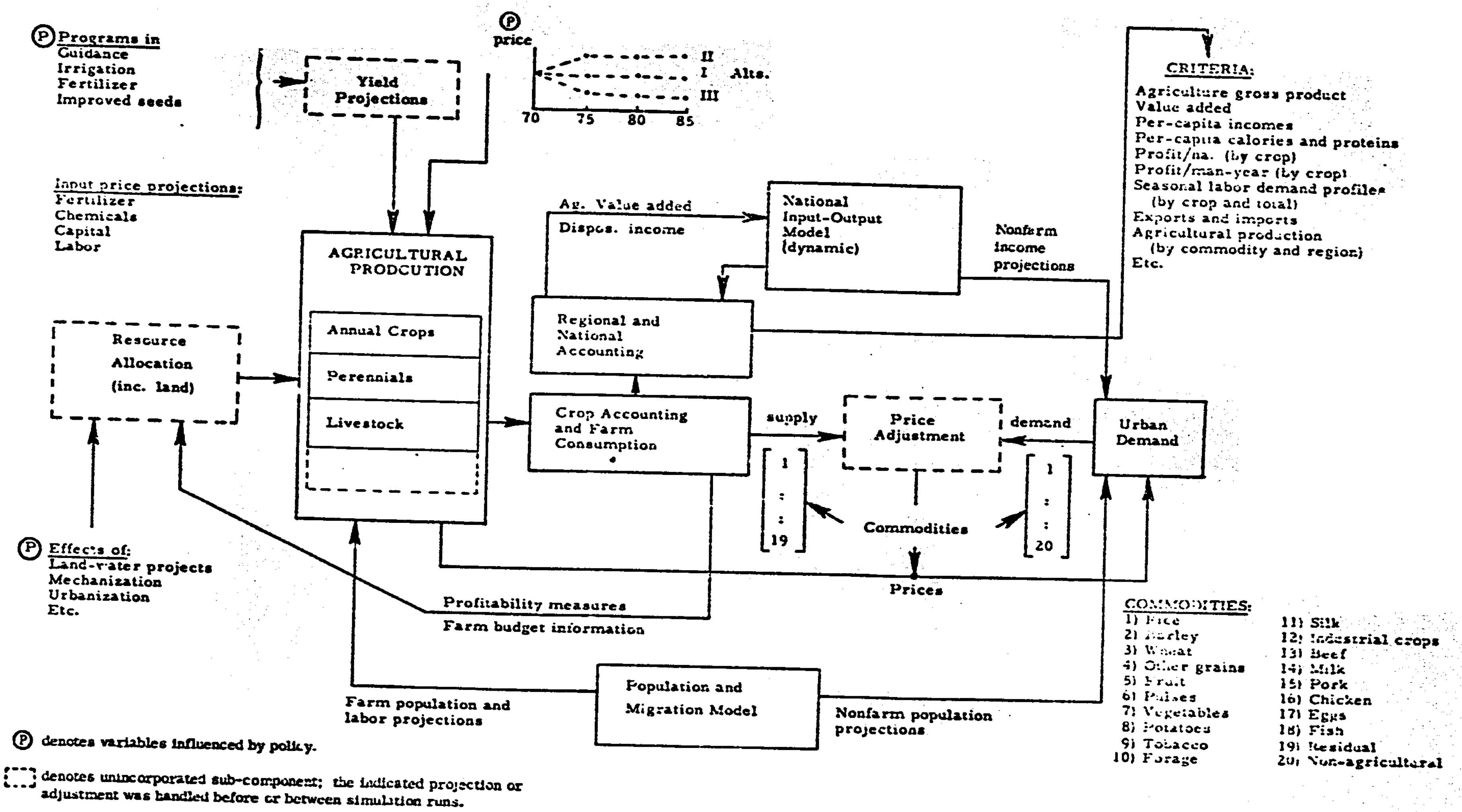

Figure 2. Diagram of Iterative Operational Model of Korean Agricultural Sector Actually Used to Project Consequences of Alternative Policy Strategies

important individual items as rice, barley and wheat and as commodity groups collections of relatively homogeneous items such as "vegetables," "fruits" and "industrial crops." On the production side, the model is disaggregated according to three regions within the country, with regions defined according to cropping patterns which are determined fundamentally by climatic and topological factors. The three regions include a "single cropping paddy" region in the northwest of the Republic where paddy rice without a second crop is the dominant pattern; the "double cropping paddy" region at the southern end of the peninsula where, due to a longer growing season, a second crop can be grown after paddy rice; and a "mountains" region in the northeast where upland cropping patterns dominate.

The model disaggregates consumption of agricultural products according to the 19 crops or crop groups mentioned above and also according to a rural/urban classification. Agricultural supply is thus computed as the difference between production and farm consumption plus losses (by items). Rural consumption by item is computed as a function of agricultural income, producer prices, agricultural population and the nutritional requirements of the agricultural population as influenced by age and sex distribution. The latter are computed by the population component of the model while agricultural income is computed by the production component. The determination of model prices will be discussed later.

Urban consumption of the 19 food items is computed for the urban population by the urban demand model shown in Figure 2. This model component also computes the demand of urban people for nonagricultural goods and services and interactions between agricultural and nonagricultural demands as influenced by growth in total urban income, urban population, and food prices. The urban demand model receives, as time varying inputs, urban population from the population component and total consumption from a macro model of the nonagricultural economy.

The population and migration model component, shown in Figure 2 and referred to above, computes the age and sex compositions of the rural and urban populations as influenced by migration rates, death rates, birth rates and population-control programs which affect the latter. This component also computes agricultural labor supply as determined by age and sex distributions and participation rates.

As indicated in the figure, the model used in making projections contains a partial model of agricultural production. The production component is partial in the sense that a number of variables which eventually will be endogenous must now be supplied exogenously. These include crop yields (MT/ha) over time as they are influenced by the three policy alternatives and land areas allocated to enterprises (by regions) by an iterative process to be described. Yield projections for the three policy alternatives were made on the basis of research and field data, estimation of the impacts of government programs to promote improved technology, and trend information. Projections of total arable land by region were made including the effects of urbanization and programs to expand agricultural land area. Agricultural price inputs to the production model are determined by policies and supply/demand interactions. This component received agricultural population and labor force from the population/migration model. Given these as major inputs the production model computes a number of variables including the following: total production by enterprise and region; seasonal production, as during harvest season; seasonal labor requirements; farm consumption and storage of output; sales (supply); gross income by crop (region specific), by region and by sector as a whole; demands for and expenditures on inputs by type (fertilizer, chemicals, capital, labor, etc.) by crop, region and sector; gross profit by enterprise and region; returns above land and labor-to-land and labor-by-crop-by-region; gross income per capita by region; and per capita rural intake of calories and protein.

Use of the Model in Agricultural Sector Projections

We will now describe the iterative approach used to make agricultural sector projections for KASS. The approach, used for each alternative in turn, will be described as it was applied to specific alternatives. To begin the iterative process, the following variables are spplied as exogenous variables to the model structure shown in Figure 2.

1. Grain prices (rice, barley, wheat) for 1970, '75, '80, '85 as determined by policy for the particular alternative,

2. A tentative set of prices for commodities with prices determined by domestic supply and demand,

3. A projection of total urban consumption for 1970, '75, '80, '85. (Won/yr.). (Consistent with Third Five-Year Plan projections urban consumption is initially assumed to grow at 9 percent under the three alternatives.)

4. Yield projections (MT/ha) by enterprise, 1970, '75, '80, '85,

5. Projections of total arable land by regions, 1970, '75, '80, '85,

6. A tentative allocation of land area to crops by region, 1970, '75, '80, '85.

Given these inputs, the model shown in Figure 2 (consisting of production, demand and population components) was run through time from 1970 to 1985. In addition to the criterion or performance variables, these models computed over time a number of variables needed for further iterations of the process being described. These variables included:

1. Deficits and surpluses (MT/yr.) by commodity by year,

2. Average producer returns per hectare and per man-year by commodity by year,

3. Agricultural sector value added by year.

The first two variables were used to make changes in commodity prices and crop area allocations for subsequent iterations. Specifically, nonpolicy determined prices are adjusted upward or downward as a function of net excess demand. Land is reallocated on the basis of relative crop profitabilities, available arable land in each region and constraints imposed by regional cropping systems. This iterative process is continued on the first two variables until supply-demand equilibrium is approximately established over the time interval, 1970-85.

Given this equilibrium it is possible to carry out iterations between the agricultural and nonagricultural models to correct for any significant changes in urban demand for agricultural commodities due to changes in agricultural imports, exports, and value added away from the values used to make initial projections of nonagricultural consumption. These iterations have not been important in Korea where agricultural income and value added are a relatively small proportion of national aggregates (about 27 percent in 1970 and 18 percent in 1985).

The results of this iterative process are summarized in the tables presented in Chapters VI and VII and Appendix B of Rossmiller, *et al.*, (referenced in the List of Publications (Section IV)).

Conclusions

Conclusions center on some of the more significant problems faced in the development and application of the model and briefly indicate areas for further work leading to the comprehensive sector simulation model.

In Korea, as undoubtedly in most other developing countries, there are problems with respect to reliable data for analysis. Particular problems were encountered in reconciling commodity production and disappearance data and in determining marketing margins. Many commodity specific supply and demand elasticities were estimated by the Korean Agricultural Sector Study team and pooled with estimates of others. Often wide discrepancies were noted. Discrepencies also were noted in different farm and urban household surveys designed to measure private consumption of basic food items.

As a result of these and other problems, it was often necessary to rework or "massage" the data. Data sources were pooled and values accepted for the model on the basis of internal consistency and credibility of the various sources. Once in the model, a number of consistency checks were used to determine areas where adjustments in model coefficients were necessary. Examples of these consistency checks include ensuring that production, consumption and loss estimates square with relatively more accurate estimates of exports, imports and carryovers. Urban and rural intakes of calories and protein must lie between certain reasonable limits at all points in time and in spite of price and income changes. One also expects that total per capita consumption of certain food groups such as grains, meat and poultry, etc., will not change significantly as relative prices of competitive members of a food group change.

These and other consistency checks identified needs for changes in model coefficients and, further, helped to identify more appropriate values for particular coefficients of the model. In a given situation, it may be possible to correct a model deficiency by altering the value of a number of model parameters. The choice can be reduced sometimes to a change in one or more particular coefficients, with the knowledge that changes in other candidate coefficients will solve one problem and create one or more others. For example, apparent surpluses existed for major food grains. A check of aggregate per capita caloric consumption of both rural and urban people disclosed that these levels were already straining the upper limits of credibility. It was therefore apparent that per capita consumption levels of these grains should not be increased but that production should be decreased, losses increased, or both.

While not a very elegant undertaking, this data "massaging" is necessary when data are unreliable. Another means used to cope with data problems is so-called "sensitivity analysis." Attention is focused on the model coefficients which are likely to have the most significant impacts on the variables of interest to decision makers and the question is posed: What are the effects of errors in model coefficients upon the <u>relative ranking</u> of various policy alternatives? How likely are data errors to result in the wrong policy choices? Only limited sensitivity analysis has been feasible within the scope of the study. Much more of this kind of investigation will be necessary and feasible with the more detailed simulation model planned for the Korean sector analysis project.

It is apparent from the above discussion that projections made for specific commodities of the model, such as production, consumption, import requirements, etc., are subject to considerable error. They should be used, therefore, with caution. It is also true that the aggregate variables of the model (income, value added, per capita incomes, aggregate price indices, total value of imports and exports, nutritional levels, etc.) are subject to relatively less error, being constructed from numerous component variables.

Future Work

We turn our attention now to a brief discussion of some of the more important unfinished tasks which lie ahead in the development of a comprehensive agricultural sector simulation model for Korea. As mentioned above, this model should be capable of applying sensitivity analysis to the many coefficients of the model and summarizing the impacts of these coefficient changes upon a number of variables of interest to decision makers. It should do so rapidly and for many coefficients adjusted either singly or in groups. It is anticipated that this part of the model will follow the approach taken in the Nigerian sector simulation.[4]

With respect to model testing and adjustment, the capability to make historical runs against past behavior of the Korean agricultural economy also must be developed. In this mode of operation, the model compares its own outputs with past time series from the real world and computes measures of "goodness of fit." These measures are then used to make model adjustments which result in an improved "fit." This overall process is another means of determining appropriate values for model coefficients which do not have accurately known values.

A number of new model components must be developed to achieve the comprehensive simulation model outlined in Figure 1. One, a livestock production component, is currently under construction. It is being designed as a general component to simulate the production of various livestock commodities (beef, pork, chicken, milk, etc.) when supplied with the appropriate inputs and coefficients for particular enterprises. The model simulates production on the basis of age specific cohorts and generates output, income, costs, etc., as they depend upon the dynamics of the production process. This component is similar in structure to the perennial crop production sub-component discussed in Rossmiller, *et al.*,[5] though inherently more complex.

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[4]Manetsch, *et al.*, *op. cit.*

[5]George E. Rossmiller, *et al.* "Korean Agricultural Sector Analysis Recommended Development Strategies, 1971-1985." Korean Agricultural Sector Study, 1972.

One of the most important components to be constructed is the so-called "production resource allocation" component. The purpose of this component is to allocate land, labor and capital to the various production enterprises of the model in response to changes in input and output prices, credit availability, availability of new technology (biological, mechanical, etc.), national programs to develop land and water resources, and other factors. Construction of this component will draw on the work of Day, *et al.*,[6] the Nigerian agricultural sector model, and other sources.

Attention also must be directed at modeling, at least at an aggregative level, government programs which influence the rural sector (land and water development, road development, rural guidance, family planning, mechanization, etc.) and their responses to changes in budget allocations.

Another important area related to public policy and its impact on sector development is food grain marketing and management. Attention must be given to modeling public purchases, sales and stocks of food grains and the public and private costs and benefits of alternative grain price policies. Attention also must be given to the modeling of private marketing and processing including investments and their impacts upon income, employment, product losses, marketing margins, etc.

Much more attention must be given in the model to interactions between the rural and urban sectors. A key issue is the impact of alternative agricultural policies upon the economy as a whole. Sub-issues include multiplier effects of expanded rural consumption of inputs from the nonagricultural sector, increased consumption of agricultural products by the nonagricultural sector, impacts on rural-urban migration rates and their consequences and effects of allocating more or less investment to the rural sector where these investments compete with nonagricultural investments for limited capital resources.

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[6] R. H. Day and Inderjit Singh. "A Microeconometric Study of Agricultural Development." (Madison: University of Wisconsin Social Systems Research Institute.) 1971.

Clearly, the unfinished business at hand will provide challenging work for investigators for years to come. In the next year or two of anticipated Korean-U. S. collaboration, work will proceed on at least two fronts. Some of the more important and tractable areas of the model will be developed to enhance its usefulness to Korea as an aid to sector planning. At the same time, institutional arrangements permitting development of a Korean team to continue this work will proceed. This human resource development would include: advanced graduate education in the many areas relevant to a sector analysis, such as economics, demography, system science, computer science, public administration, technical agriculture, etc.; "on the job" experiences; and thesis study in areas directly relevant to Korean agricultural sector analysis and development.

Activities Related to Nigeria

Fiscal 1972 saw the project's activities in and with Nigeria take two related forms. At the request of the Nigerian government, simulation analyses were made of some key policy issues facing the Federal Ministry of Agriculture and Natural Resources (FMANR) in its preparation of the "Perspective Plan for Agriculture in Nigeria to 1985." Concurrently with this work, and supported by it, efforts were made to develop a long-term project in Nigeria to institutionalize the generalized system simulation approach within the planning and policy-making apparatus in the FMANR.

The first policy simulations resulted from Mike Abkin's trip to Nigeria in June 1971 under Contract AID/afr-786 and were done under AID/csd-1557. The report, "Simulation Analysis of NADC Policy Recommendations" dated July 23, 1971, was presented to the FMANR in August by Glenn Johnson along with a memorandum from Dr. Johnson to Mr. Julius Eweka, Chief Planning Officer of the Federal Department of Agriculture, FMANR, outlining the procedures whereby a simulation project could be implemented in Nigeria with money from AID/csd-2975.

Dr. S. O. Olayide--of the Department of Agricultural Economics and Extension, University of Ibadan, Ibadan, Nigeria--visited East Lansing in November and December of 1971 to familiarize himself with the simulation model and to conduct some policy simulations. A paper reporting results of those simulations--"Agriculture and the Growth of the Nigerian Economy: Results of Policy Simulation Experiments" by S. O. Olayide, Michael H. Abkin and Glenn L. Johnson--has been submitted for publication in the Nigerian Journal of Social and Economic Research.

In January 1972, Mike Abkin completed his doctoral dissertation, supported under this contract, in the Department of Electrical Engineering and Systems Science at Michigan State University. The dissertation's title is "Policy Making for Economic Development: A System Simulation Model of the Agricultural Economy of Southern Nigeria."

Based upon the work performed in July 1971 (discussed above) for Nigeria's National Agricultural Development Seminar, and based upon Dr. Olayide's work in East Lansing in December, the FMANR requested two simulation experts to spend 4-6 weeks in Nigeria gathering data for further simulation analyses of policies under consideration for the Perspective Plan.

Mike Abkin spent five weeks in Nigeria in March and April 1972 both in the above effort and in promoting a long-term implementation project. The latter resulted in the presentation of a formal recommendation for such a project to the Editorial Board for the Perspective Plan (made up of department chairmen and planning officers of the FMANR) from its consultants: "Project Proposal on Implementing the Simulation Approach to Agricultural Sector Analysis in Nigeria" by Dupe Olatunbosun and S. O. Olayide (see Appendix). An official request for such a project has not yet been made.

Upon Dr. Abkin's return to East Lansing, policy simulations were conducted on policies related to the production of agricultural commodities. The report, "Production Campaigns with Input Constraints and Various Tax Policies: A Simulation Analysis," was sent to Nigeria and presented to the Editorial Board in mid-June.

Earl Kellogg of the University of Illinois spent three weeks in Nigeria in June as the second simulation man requested by the FMANR. His task was to investigate policies related to the cattle industry of northern Nigeria.

Upon his return, Dr. Kellogg spent time in East Lansing making the simulations and then returned to Illinois to analyze the results and write his report, to be forwarded to Nigeria. That report is being prepared at this moment.

Throughout the year, work has progressed to improve and further develop the Nigerian model. One working paper has come out of such work--"Modification of the Northern Regional Model to Account for a Variable Proportion of Food Self-Sufficiency" by Forrest J. Gibson, dated January 24, 1972--although the modification reported therein has not as yet been incorporated into the model.

In addition, each time policy simulations were made--Olayide's, Abkin's and Kellogg's--the model was improved and extended as necessary for the desired simulations. Not only were specific features added as needed--e.g., the capability of investigating the consequences of exogenously specified biological and chemical input constraints, and the capability of considering supplemental feeding with groundnut and cotton-seed cake in the cattle industry--but general modeling and programming deficiencies and errors were spotted and corrected, and data estimates were improved.

Although not supported by Contract 2975, two graduate students, Kwong-Yuan Chong and Olasupo Ladipo, have been working on theses directly related to agricultural sector analysis in Nigeria.

Chong's thesis using the Nigerian agricultural system simulation model analyzes the major policy issue which the western Nigerian cocoa economy faces. Specifically the study traces the time paths (from 1970 to 1985) of some of the more crucial performance indices of the cocoa sector, namely, the total output of cocoa, the cocoa acreages, the foreign exchange generated from cocoa export, the government tax and revenue from cocoa marketed, the government expenditure for production campaigns and the returns to farmers using various assumptions of: (a) the expected world price of cocoa, (b) government and Marketing Board revenue and producer pricing policies, and (c) the program features of the production campaigns. Based on the policy experiment, the most efficacious strategy is discussed.

Ladipo has been developing a simulation model for the fisheries subsector of the agricultural sector of Nigeria. The Ministry of Agriculture and Natural Resources in Nigeria has four departments: one for agriculture, one for livestock, another for forestry and a fourth for fisheries. Ladipo's model draws on components of the Nigerian agricultural sector model, which deals primarily with crop and livestock products. Conferences are planned at East Lansing with the Director of the Fisheries Department to investigate the possibility of doing additional simulation work on the fisheries subsector in Nigeria under this contract. It is contemplated that the Fisheries Department may acquire the services of Ladipo through a contractual arrangement between: (1) the Federal Ministry of Agriculture and Natural Resources and (2) the University of Ife, Ladipo's employer. MSU could furnish matching services under this contract.

Simulation of the Beef Industry In Northern Colombia

Alvaro Posada, for his doctoral dissertation work at MSU, is currently developing a simulation model of the beef industry in northern Colombia by adapting model components which had previously been developed for work in Nigeria and Brazil.

Colombian Agriculture and Its Beef Industry

Common targets for agricultural development in Colombia have been summarized as follows: (a) to increase output to meet the needs of a rapidly growing population; (b) to generate new jobs in the rural sector to decrease the number of unemployed and slow down the pace of rural to urban migration; (c) to increase the income of the rural population in order to broaden the economic base; (d) to generate new sources of foreign exchange now depending mainly on coffee (65 percent--other major sources being petroleum, sugar, cotton and bananas).

Agricultural output in Colombia increased at an average annual rate of 3.3 percent from 1950 to 1967, or at about the same rate as population. Throughout the whole period, output of livestock and livestock products rose at an average annual rate of around 3.7 percent, a little above the rate of population increase, beef being the primary product. However, cattle slaughter has not kept pace with population during the past two decades.

Possibilities for expanding the cattle population and beef exports have been assessed as favorable, and a plan for expansion is under way.

The causes determining the low cattle yields and the supply difficulties encountered in respect of cattle commodities are manifold. Among the most important are the heavy incidence of animal pathology, malnutrition, problems relating to breeding techniques, unsatisfactory farm management, and, lastly, defective marketing and slaughtering systems.

In Colombia, stock farming is carried on in a variety of climates and zones of differing ecology. This naturally raises a wide range of problems and is responsible for the fact that its characteristics vary from one area to another. The principal stock farming activity, besides milk production, is the breeding, raising and fattening of cattle. The country has been divided into three temperature zones: (1) cool, (2) warm, and (3) hot. The largest and most important climatic zone for beef cattle production is the hot zone. Included in this zone are the areas below 1000 meters in altitude with mean temperatures of greater than 23°C. This beef producing zone has been divided into five clearly differentiated stock-farming areas (see Figure 3).

1. The Atlantic Coast which has approximately 9.7 million hectares in pasture and a livestock population of 7.5 million head.
2. The Central and Upper Magdalena Valley which has approximately 5.6 million hectares in pasture and a livestock population of 4.3 million head.
3. The Cauca Valley which has approximately 1.2 million hectares in pasture and a livestock population of 1.25 million head.
4. Eastern Plains which has approximately 16 million hectares in pasture and a livestock population of a 1.3 million head.
5. Southern Region which has a livestock population of 0.37 million head.

The primary focus of this study is on the beef production process with only rudimentary considerations of the related crop sub-sectors and the marketing and processing elements of the beef sub-sectors. Consideration will also be given to the foreign exchange and employment components of the

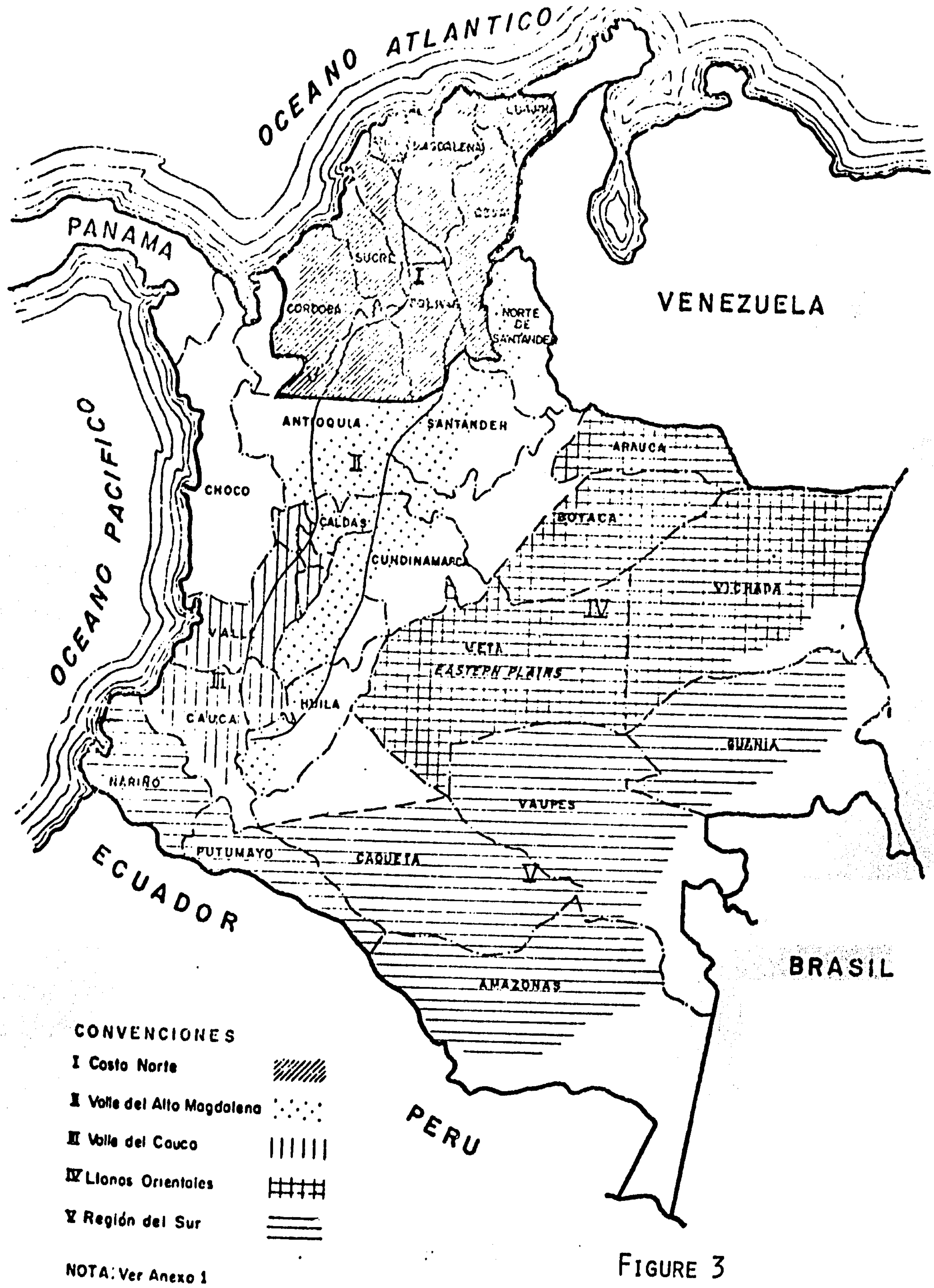


FIGURE 3

PIMUR

REGIONES DE MAYOR PRODUCCION PARA GANADO DE CARNE EN COLOMBIA

FUENTE:
ICA, "Requisitos y potencial para la exportación de carne en Colombia en la década de 1970." Max F. Boxer, Sep. 1969

system. The study will be restricted to the Atlantic Coast region where approximately 50 percent of the beef cattle population is concentrated. In addition, (1) this is a major surplus area which provides approximately two thirds of the cattle that move in interregional trade; (2) there are vast potential farming areas especially suitable for beef production; (3) the area has easy access to modern port facilities; and (4) there are expanding facilities for modern slaughter and meat processing.

General Model Description

The model being developed is of a macroscopic nature which would broadly display the significant system interactions and the influences of major industry modernization policies. In the model (see Figure 4), the livestock population of northern Colombia is disaggregated into two populations--one traditional and one managed using modern techniques. The modern operation assumes that the level of husbandry has been upgraded, i.e., diseases and parasites are controlled and improved breeding techniques and range management practices are used.

Four modern alternatives will be evaluated:

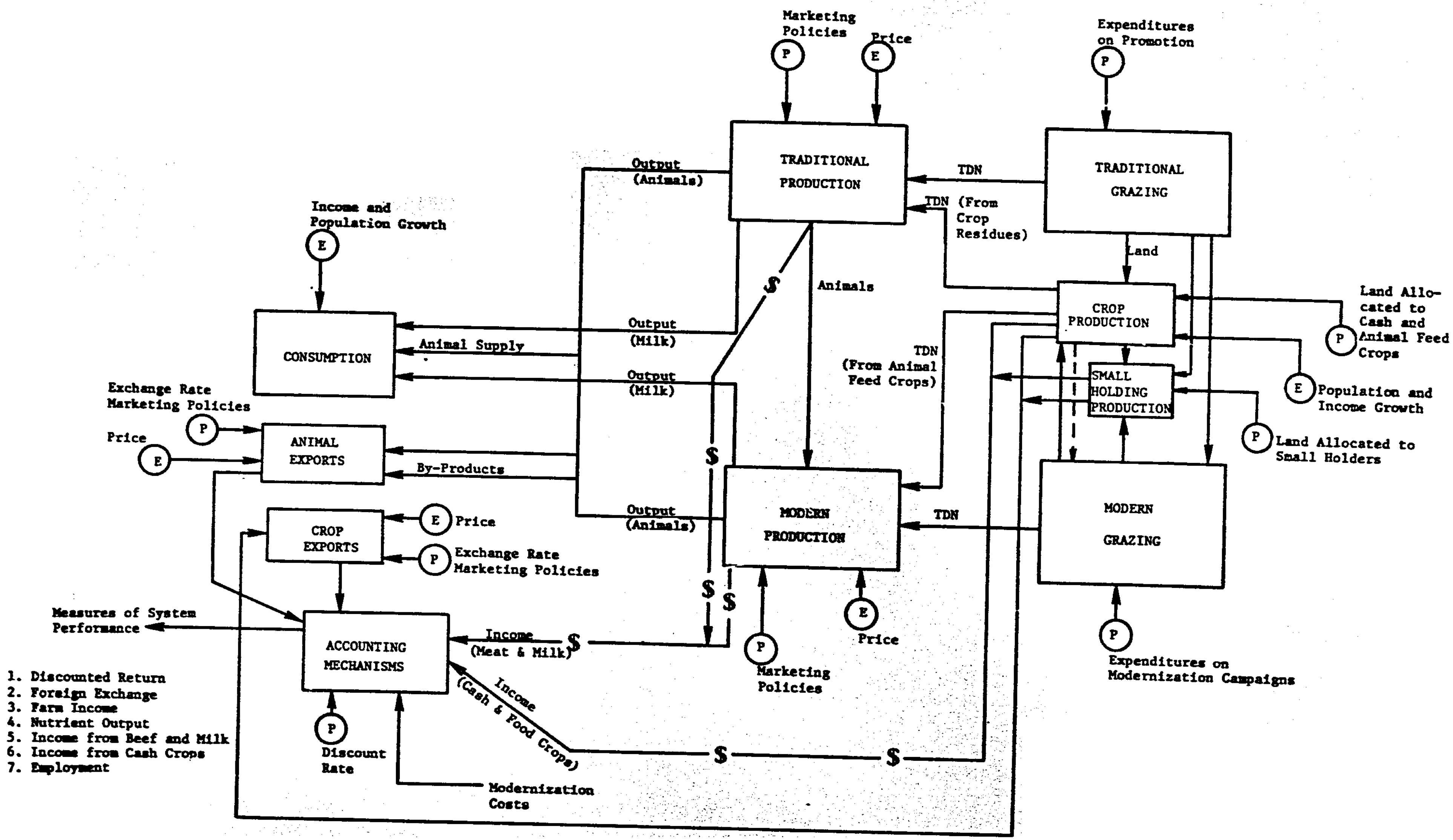
1. The first is the improvement of the existing system of production. Pasture lands are kept with the grass species already present. Fences and stock water supply are established to permit the beginnings of health protection measures; proper grazing rate and pasture rotation to increase fodder production and improve nutrition.

2. Same ranching practices as in Alternative 1 with artificial pastures substituting for natural pastures. Improved grasses and fertilizers are used to increase fodder production.

3. Same as in Alternative 1 with forage crops being used to provide feed during the dry season.

4. Same as in Alternative 2 with forage crops being used to provide feed during the dry season.

All four alternatives require both government and private participation. Ranchers must be willing to make the expenditures needed for an upgraded operation and be engaged in a more direct supervision of the ranch (private decision making). The government has to create the incentives and the supporting services which will be responsible for mobilizing public and private resources.



P = Policy Variable
E = Exogenous Variable

Figure 4. Functional Flow Diagram of Livestock Macro-Model

The computer simulation model is composed of five basic components or building blocks (see Figure 5). The first, the land allocation and modernization decisions component, allocates land between cash crops and livestock in the subregions of competing farming activities. Land use decisions are based on perceived relative profitabilities and the availability of information, either from farmer-to-farmer in a diffusion process or from extension agents as part of modernization promotion efforts. Expansion of total cultivated land and/or of modern cattle operations may occur as a result of these economic decisions.

The second principal component takes the allocation of land from the land allocation component and, given product prices and yields, computes agricultural production.

A third unit of the model (Price Generator) generates world, market, and producer prices. Producer prices are exponentially averaged; these averages are used for the projections made to determine profitabilities in the land allocation component.

The remaining two components are the primary entry and exit points of the system. As policy entry points, cattle production campaigns are specified and conducted, price control, export tax and/or subsidy, sales tax, cattle inventory tax, and credit policies are set. Finally, in the criteria and macrobudget accounting component, several alternative criteria functions which might influence a policy maker's choice of development programs are generated.

Software Library

Though work was started on a software library, it was delayed in accordance with the original wording of the contract by the press of work resulting from the activities reported above. These research activities have helped to indicate how the software library should be organized.

Further work was carried out in improving the documentation of the Nigerian model and converting the program to run on IBM 360 computers in order to facilitate its general distribution. This work is not yet complete, however.

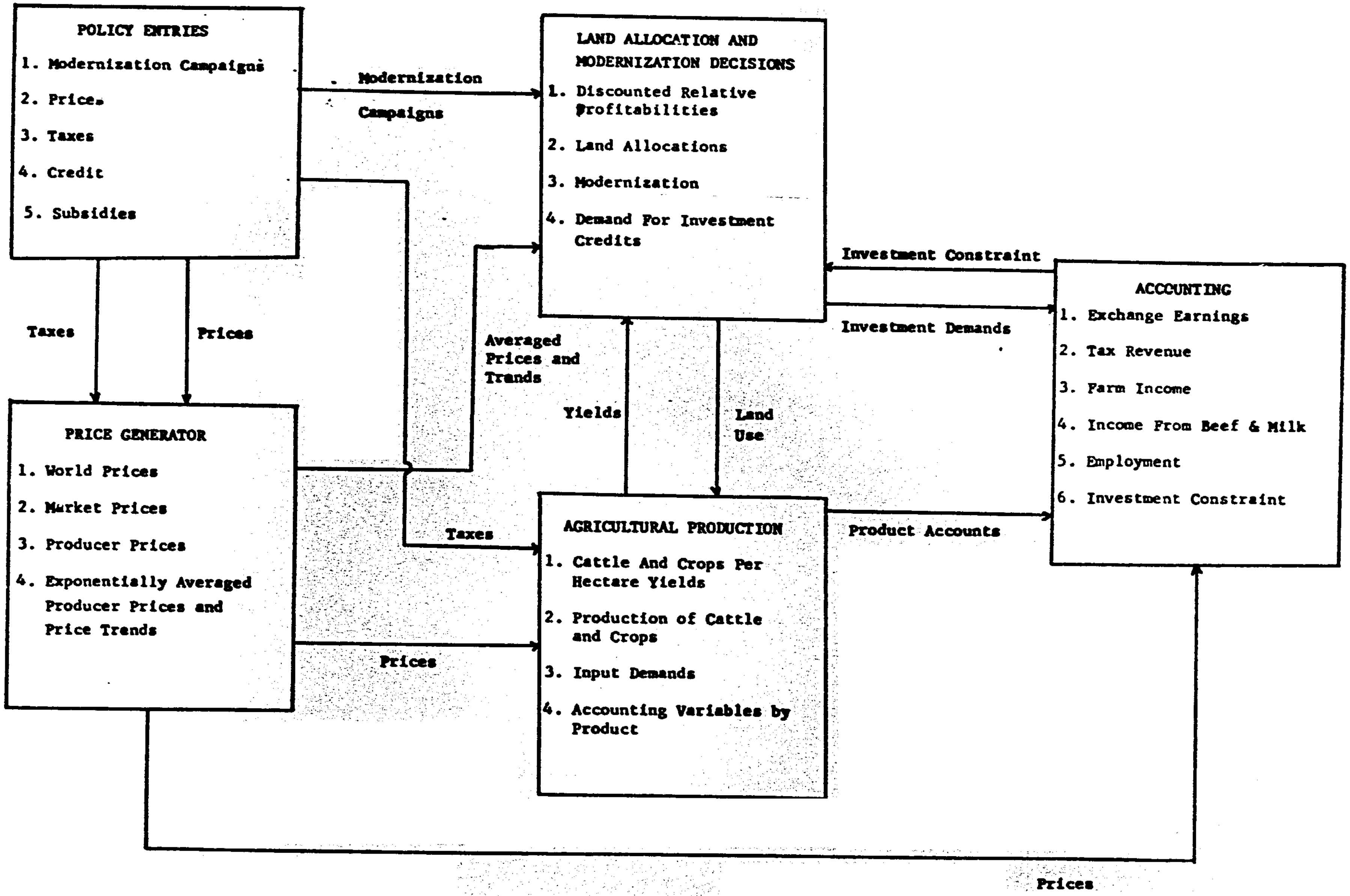


Figure 5
BUILDING BLOCKS OF THE COSTA BEEF MODEL

As part of initial library activities, copies of the current versions of the Nigerian beef model and the Korean demographic model were made available to Dr. Albert Halter of Oregon State University for a project he is conducting in cooperation with the Venezuelan government.

The Korean demographic model was also made available to Dr. James McKenzie of the Canadian International Development Agency for a research project he is undertaking in Uganda.

Plans are being formulated for the organizational and operational structure of a formal "agricultural system simulation library."

Conferences and Seminars

On February 27-29, 1972 Glenn Johnson, project leader, participated in a seminar sponsored by the Agricultural Development Council on problems of validation and verification in connection with agricultural sector analyses. This conference was organized at Purdue University by Visiting Professor, Stan Johnson.

On April 24, Glenn Johnson, project leader, and Marvin Hayenga participated in a simulation conference at Iowa State University. That conference was sponsored by one of the new regional agricultural research committees which was investigating the possibility of using simulation models of the type developed under this contract in analyzing domestic agricultural development problems.

Staff supported by this contract participated in the planning and presentation of a three-day seminar on "The General Systems Analysis Approach for Agricultural Sector Analysis and Planning Including Component Policies, Programs, and Projects" sponsored by the Agricultural Development Council and held at Airlie, Virginia, May 1-3, 1972.

On May 11, 1972, project staff presented a seminar for interested members of the MSU community on current work in applying the general system simulation approach to agricultural sector analysis. Discussion at the end of the seminar centered on how these techniques can be and are being applied in the related fields of health, education, industry, transport, population, technological research, nutrition, public administration, etc. which are also important for overall national development.

Site Visit

On May 5, 1972, the project hosted a site visit by a Project Review Committee of the AID Research Advisory Committee (RAC).

In its report to the RAC, the Project Review Committee reached the following general conclusion with regard to the Korean Agricultural Sector Study:

> The Review Committee was impressed by the speed and effectiveness of this initial effort. The interaction or feedback between the sector studies and the simulation effort appears to have lead to rapidly decreasing costs in the implementation of the sector-simulation methodology. The Committee would anticipate that costs would continue to decline in the future. It regards the simultaneous sector-simulation effort as essential. It commends the MSU-GOK team for its effectiveness in moving forward on both fronts.

and made the following recommendation:

> The Committee recommends that AID proceed with the funding of the project (AID/csd-2975) for the remaining period of the contract (to June 30, 1974).

At several points throughout its report the Review Committee made the following specific recommendations:

> It is the judgment of the Committee, of the MSU team, and of the Korean and Nigerian participants at the review that much greater attention will need to be given to specialized non-degree oriented training if such capacity is to be adequately institutionalized. The Committee urges the MSU project director and senior staff to give particular attention to the training effort needed to meet this objective. The Committee urges the AID to make sure that the training effort is adequately funded. It appears likely that both the training activity and frequent consultation with MSU Personnel will be required beyond the term of the present contract (June 30, 1974). The AID should make provision for a continued linkage between the national sector simulation and program analysis efforts in the two countries and the staff capacity at MSU beyond the term of the present contract.

There does remain, however, the unsolved problem of model validation. At present, procedures for validation "in the small" - for the separate micro-modules - seem more advanced than for validation "in the large" - for the macro-implications of model projections. This is an issue to which the MSU project should, consistent with the extensive experience of its staff, give considerable attention.

On May 15-16, 1972 the Research Advisory Committee voted to accept the recommendations that:

(1) AID proceed with the funding of the project for the remaining period of the contract (June 1974); and

(2) The contractor and AID give special consideration to participation of indigenous personnel and methodological aspects of research activities, two of the points raised in the review subcommittee report.

III. OUTLINE OF FUTURE WORK

1972-73

1. The Korean Agricultural Sector Study will be further developed and work will be continued on training personnel and on institutionalizing a Korean capacity to maintain and continue it.

2. The Nigerian and Colombian beef project analyses will be completed.

3. Two additional sector policy, program and/or project studies will be initiated and, perhaps, completed.

4. The software library will be approaching operational readiness.

5. In response to requests from AID/W, USAID mission and from other agencies addressed to AID/W including regional as well as federal bureaus, USAID missions and/or MSU and on the basis of mutual agreement between the contractor and contractee, MSU will help organize, conduct and/or participate in conferences to further develop, explain, extend and apply the models, model components, empirical results and the approach produced and developed under this contract. The budget provided herein for that purpose will not be spent except as a result of such requests and mutual agreements. That budget is subject to augmentation in accordance with such requests and agreements and subject to the availability of funds. This activity may involve U. S. mission, host country and/or other personnel.

6. Professional and semi-popular reports will be published in addition to directly applicable reports growing out of policy, program and project analyses.

1973-74

1. The contractor will, hopefully, have developed a Korean capacity to use, apply and further develop computerized, systems-science simulation models and will have made, in addition, substantial progress in developing such a capacity in at least one more country.

2. The contractor will be increasingly responsive to requests from host countries, USAID missions, AID/W and international donor and lendor agencies for research, assistance and training programs. As these responses are expected to be of substantial volume, it is anticipated that additional funding may be required by the first half of the third year.

3. The software library should be operating and continue to develop, and questions will have to be raised concerning its more ultimate nature, its organization and location and financial support in subsequent years.

4. Item 5 for the second year will be continued in the third year.

Subsequent Years

Specific plans have not been developed for subsequent years. It is clear that there is continuing need for this type of applied research. Therefore, it is noted that plans will have to be laid and finances developed before June of 1974 to: (1) prevent dispersal of the personnel developed under this project, and (2) to provide financial resources to continue this activity. It is planned, therefore, to establish before June, 1974, a capability at MSU to be used beyond June, 1974 to respond to requests from the U. S. government (including its overseas agencies), international agencies, foreign governments, and grantor and lendor agencies for simulation analyses of policy, program and project problems at the agricultural sectoral and sub-sectoral level. Because it is also clear, as of the date of this amendment, that the approach followed in AID/csd-1557 and under this contract is likely to be useful in such related sectors as health, education, industry, transport, population, technological research, nutrition, public administration, etc. The capacity referred to above is also to be able to respond to requests from workers in such fields and particularly, those in other AID research contracts for consulting services and, perhaps, joint participation in constructing models in such areas. In this connection, it is anticipated that the present contract will either be extended beyond 1974 or replaced with a new contract to utilize this capacity. To that end, additional monies may be obligated under this contract before June, 1974, to further develop and utilize this capacity.

IV. LIST OF PUBLICATIONS

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deHaen, Hartwig. "The General Systems-Analysis Approach for Agricultural Sector Analysis: Ability to Handle Various Contributing Techniques." Discussion Paper prepared for delivery at the Agricultural Development Council Conference on: The General Systems-Analysis Approach for Agricultural Sector Analysis and Planning Including Component Policies, Programs and Projects, May 1-3, 1972.

Gibson, Forrest J. "Modification of the Northern Regional Model to Account for a Variable Proportion of Food Self-Sufficiency." East Lansing: Michigan State University, January 24, 1972.

Olayide, S. O.; Abkin, M. H.; and Johnson, G. L. "Agriculture and the Growth of the Nigerian Economy: Results of Policy Simulation Experiments." To be submitted for publication in a Nigerian journal. December, 1971.

Rossmiller, George E., *et al.* "Korean Agricultural Sector Analysis and Recommended Development Strategies, 1971-1985." Seoul, Korea: Agricultural Economics Research Institute; and East Lansing, Michigan: Department of Agricultural Economics, Michigan State University, 1972.

Appendix

PROJECT PROPOSAL OF IMPLEMENTING SIMULATION APPROACH TO AGRICULTURAL SECTOR ANALYSIS IN NIGERIA

The "Generalized Simulation Approach to Agricultural Sector Analysis" with special references to Nigeria, produced by the Michigan State University Simulation Team under USAID Contract No. AID/csd-1557--Agricultural Sector Models, is a useful document which calls for a solid project designed for its practical implementation. In this short proposal, we are of the firm conviction that a one-year project for this implementation phase will entail:

(i) the training of Nigerians to build, maintain, operate and analyze the results of simulation;

(ii) the transference of the current MSU models to a computer in Nigeria;

(iii) continuing development of the current models and beginning the construction of new models in the framework of a library of models (see chart 1);

(iv) policy applications of the models as called for;

(v) research necessary in support of (iii) above, and

(vi) setting up an office and institutional relationships to carry out the implementation both during the year of the proposed project and thereafter on a continuing basis.

This short project statement is discussed under three headings which are the Organizational Structure, Staff Requirements and Costs/Financing. We shall discuss each of these briefly and detailed costings in money, men, and materials will be worked out later in consultations with the Federal Ministry of Agriculture and Natural Resources, Lagos Nigeria.

I. Organizational Structure

This will comprise of three integrated components.

First is the Core Modellers/Simulators Group which will be based in the Planning Division of the FMANR, under the supervision of the Chief

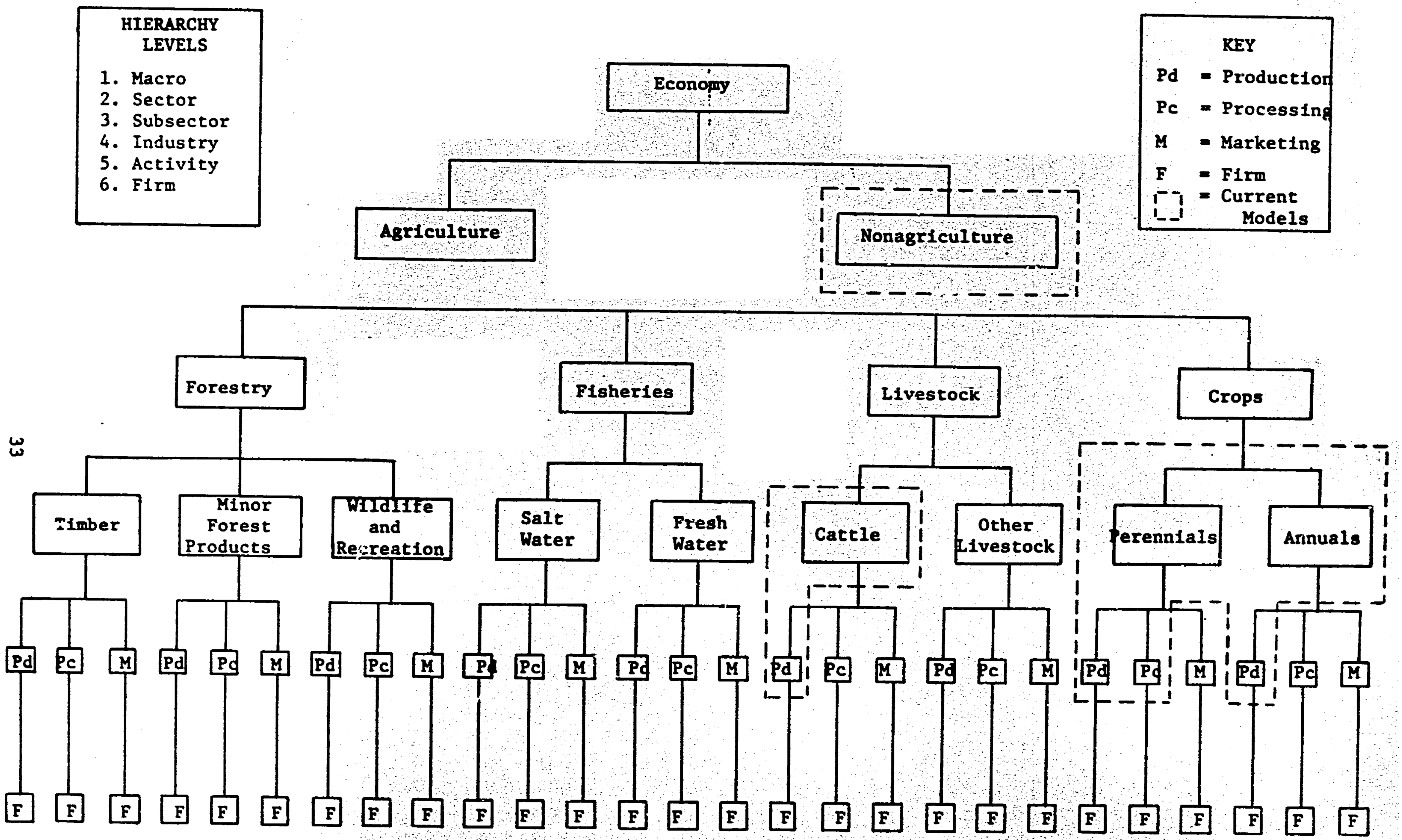

Figure 1

A Library of Models

Agricultural Planning Officer. This Core group will perform the following functions:

(i) Providing coordination of planners' needs with respect to data collection, research, theoretical modelling, computer modelling etc.

(ii) Building, maintaining, and operating computer models in the library.

(iii) Performing behavioural analyses of the results of policy simulation experiments.

(iv) Training Staff in States MANR Planning Division in series of Seminars and Workshops on the content, use, requirements, implementation and interpretation of simulation results.

(v) Liaison with research bodies on needed expansion and research re-orientations in sectoral analysis for micro and macro level planning purposes.

(vi) Building up data library from research and survey reports and up-dating them.

Second is the unit consisting of planners and policy makers. This unit will comprise heads of Divisions of FMANR and the Chief Planning Officers in consultation with their States Counterparts. Their function will be:

(i) To periodically review and set out in clear terms the official and ever-changing agricultural policies of the government.

(ii) To interact with modellers/simulators in preparing and quantifying these policies for modelling so as to simulate effects of various alternatives.

(iii) To assess, validate for purposes of plan/policy implementation the results of policy simulations.

Third, is the unit comprising researchers in Nigerian Universities and research institutions. The functions of this group in integrating with Core Simulators will be:

(i) To constantly select their research projects from "Research Projects For National Agricultural Development" as published by the National Agricultural Research Council.

(ii) To collect and collate their research data and results in a manner that could provide dependable materials for model building.

(iii) To actively participate in multi-disciplinary and basic research, theoretical models and developing theories that are required in building and/or improving computer models.

(iv) To interact with modellers and policy makers in defining, validating and reviewing the results from models simulation.

(v) To use models for their own purposes of training and research.

(vi) To constantly/periodically define with policy-makers and modellers the necessary simulation experiments as called for by changing agricultural policies under economic development.

(vii) To perform economic analyses of and draw socio-economic conclusions from the results of simulation experiments for presentation to policy makers.

The first group will be in constant touch with the second and third groups, if they are to be effective. In this case, it seems absolutely essential to set up an Advisory or Steering Committee made up of people from the three groups with a "Project Director" selected from among member of the Committee and who is capable of providing leadership in the plans and policies for effecting a valuable fusion of the three groups.

II. Staff Requirements.

The Staff requirements dealt with here will essentially be those of the Core Modellers/Simulators. These include:

(i) 1. Systems Analyst with PH.D. - to work on full-time basis for 1 year - preferably from MSU Simulation Team.

(ii) 1. Computer Programmer - full time - may be loaned to begin with, but his counterpart should be attached and trained on the job.

(iii) 2. M.SC. or PH.D. in Agricultural Economics or Computer Science who will be permanent staff.

(iv) 4. Technical Staff - one to represent each of the divisions, Agriculture, Livestock, Forestry and Fisheries.

(v) 2. Consultants from University or research community - Part Time.

In selecting people for the third unit, the FMANR will send information to all Nigerian Universities and Research Institutes asking staff who are interested in Systems Simulation as applied to Agricultural Sector Analyses to fill specified forms. On this basis selections will be made and those selected will work on part-time basis with the other groups. Also in this group will be M.Sc. and Ph.D. students who will work on part-time basis in appropriate situations designed to assist in research, data collection and modelling that might form part of their dissertations.

III. Costs - Financing.

First, simulation experiments will take roughly 5 to 7 hours of computer time per month. This might cost from £250 - £500 per month, depending on the user costs of the computer installation employed. This monthly usage will decrease substantially as models are improved, revised and stabilized.

Second, administrative costs will include payments for one full-time Stenographer/Typist, office equipments, stationeries and supplies, telephone, postage and other communication costs, in-country transportation and hotel expenses, office overhead costs, etc.

Third, the FMANR in cooperation with National Agricultural Research Council will make annual allocations for research oriented to improving modelling variables and data-gathering.

Fourth, during the first year of the proposed project, the expatriate systems analysist and the programmer from the MSU simulation team will be in Nigeria with counterparts attached to them for on-the-job training. Expatriate salaries, fringe benefits and international travels will be funded by MSU (possibly from funds of the Technical Assistance Bureau of USAID/Washington, under contract AID/csd-2975), whilst local housing and local transport will be supplied by FMANR or by the USAID mission in Lagos or by MSU depending on worked out negotiations.

Fifth, Nigerian professionals on the Core Group will be paid from the funds of the FMANR, as will other local administrative costs. Necessary overseas training and short-course in East Lansing for any of the Nigerian professionals would be financed either by MSU or FMANR or both depending on negotiated settlements.

Sixth, office and computer services in East Lansing will be supplied by MSU while eventual computer costs in Nigeria will be borne by the FMANR or MSU or both, depending on acceptable negotiated settlements.

Lastly, after the successful completion of the one-year project, everything will be in the hands of FMANR and its trained staff. Thereafter all costs will be borne by the FMANR, except for periodic consultancy visits to and from MSU by staff on both sides, which again is a subject for negotiation.

(SIGNED)

DR. DUPE OLATUNBOSUN
Consultant FMANR.

(SIGNED)

DR. S. O. OLAYIDE
Consultant FMANR.